APPARATUS AND METHOD FOR CONTROLLING DATA WRITE OPERATIONS IN OPTICAL STORAGE SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an apparatus and method for controlling a data write operation in an optical storage system, and particularly to a write-control apparatus and method used in an optical storage system wherein a write-control signal associated with the write operation is rapidly charged to an adapted level for writing data onto a compact disk (CD) so as to avoid malfunction in data writing.

2. Description of Related Art

Currently, the optical storage systems and corresponding media are becoming more and more popular. Thereby, the electronic devices, such as notebook computers, personal computers, are equipped with a CD re-writer (CD-RW) for writing data, images, etc. to write once read multiple (WORM) or recordable CDs so as to provide a great convenience to users.

Referring to FIG. 1, the architecture of a conventional CD-RW is illustrated. The CD-RW includes a read-control device 10, a write-control device 20, and a read/write head 30. When the conventional CD-RW is desired to read or write data, the read/write head 30 generates a current i_D flowing through a laser diode 301 so as to derive a laser light beam to project onto a CD 40 for reading or writing data operations. A monitor diode 302 of the read/write head 30 generates a current i_M based on the laser light beam according to the laser diode 301. An operation amplifier 303 generates a feedback control signal FPDO based on the current i_M for performing an

automatic power control to the read-control device 10 and the write-control device 20.

When reading data, a driving IC 304 of the read/write head 30 only enables a read-enable signal ENR in accompanied with a current i_D described as in eq1(a) flowing through the laser diode LD. When writing data, the driving IC 304 of the read/write head 30 enables a read-enable signal ENR and a write-enable signal ENW so that a current i_D described as in eq1(b) will pass through the laser diode LD. The current i_D in the laser diode can be described as follows:

$$i_D = \begin{cases} \dfrac{\mathrm{VRDC}}{\mathrm{Rset1} + \mathrm{R_A}} \times \mathrm{gain1} & \text{if ENR} \in \text{enable} \quad \text{eq1(a)} \\ \dfrac{\mathrm{VRDC}}{\mathrm{Rset1} + \mathrm{R_A}} \times \mathrm{gain1} + \dfrac{\mathrm{VWDC}}{\mathrm{Rset2} + \mathrm{R_B}} \times \mathrm{gain2} & \text{if ENR, ENW} \in \text{enable} \quad \text{eq1(b)} \end{cases},$$

where gain 1 and gain 2 are current gains of the INR and INW channels, VRDC and VWDC are read-control signal and write-control signal, respectively, the R_A and R_B are internal resistors of the driving IC304. Obviously, the current i_D flowing through the lased diode LD is different as shown in FIG. 2 when the laser diode 301 reads or writes data. Generally, the laser diode 301 needs a large amount of current for writing data to a CD 40.

The circuit of the write control device 20 is illustrated in FIG. 3. The sampling frequency of the sampling and holding circuit 201 is far higher than the variation of the feedback voltage FPDO. Therefore, the output voltage of the sampling and holding circuit 201 is represented by FPDO. The voltages of nodes in the circuit of FIG. 3 are analyzed as the following:

$$\mathrm{dV2} = \mathrm{Vref} - \mathrm{FPDO}$$

$$\mathrm{VWDC} = \mathrm{DAC2} + (\mathrm{Rf2}/\mathrm{Ri2})*(\mathrm{DAC2} - \mathrm{dV2}*\mathrm{G12})$$

where Rf2/Ri2 ≒ 150. Thus, the output voltage of the operation amplifier 202 is varies from 0.5 to 4.5V. Basically, when the write-control device 20 is to be operated normally, the operation amplifier 202 must operate within a linear regionto prevent its output voltage from being saturated. Namely, when the second digital-to-analog control signal DAC2 is approximately equal to dV2*G12, the operation amplifier 202 will operate in the linear region. From the above, it is known that since the write-control device 20 is a negative feedback configuration, the operating point Q will be found automatically. When the write control device 20 operates around the operating point, the voltage of the writing-control signal VWDC delivers to the read/write head 30 will be at a working voltage with little disturbances. The perturbation frequency is about 20Hz~20KHz. Thereby, a capacitor C2 is installed in the circuit for canceling the vibration. Likewise, a capacitor C1 is installed in the read-control device 10 for the same purpose.

When writing data to a CD, a time period control signal WLDON is at a high level.However, the write-control signal VWDC will be charged to an operating voltage slowly as shown in FIG. 4 due to the effects of the capacitor C2. As illustrated, in time period dT, if the write-control signal dose not achieve the operating voltage, the current i_D of the laser diode 301 illustrated in formula eq1(b) cannot reach a current sufficient for writing data onto a CD. As a result, a malfunction in writing data to a CD may occur.

SUMMARY OF THE INVENTION

In one embodiment, thedisclosed apparatus for controlling data write operation in an optical storage system includes an operational amplifier having a positive input end, a negative input end and an output end for outputting a write-control signal at the output end. The operational amplifier may operate under one of a short-term mode, a long-term mode and a

closed-loop mode. In the short-term mode, the operational amplifier is formed as a voltage follower for initializing the write-control signal. In the long-term mode, the operational amplifier charges the write-control signal. In the closed-loop mode, the charged write-control signal may be employed to record data onto a CD.

In the embodiment of, the disclosed method for controlling a data write operation in an optical storage system includes the steps of: executing a short-term mode for initializing a write-control signal by virtual ground; executing a long-term mode for charging the write-control signal by virtual ground; and executing a closed-loop mode for employing the charged write-control signal for writing data to a compact disk.

In the embodiment, the read/write device used in an optical storage systemencompasses a read-control device for generating a read-control signal in response to a feedback control signal; and a write-control device having an operational amplifier for generating a write-control signal in response to the feedback control signal. The operational amplifier is formed as a voltage follower for initializing the write-control signal when operating under the short-term mode. Under the long-term mode, the operational amplifier charges the write-control signal. The charged write-control signal is used to control the writing of data to a compact disk when the operational amplifier is operated under a closed-loop mode. The read/write head generates a laser beam in response to the read-control signals, the write-control signals, a read-enable signal, and a write-enable signal, wherein the read/write head generates a feedback signal based on the laser beam for being fed back to the read-control device and the write-control device.

The various objects and advantages of the present invention will be more readily understood from the following detailed description when read in conjunction with the appended drawing.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic view showing a read/write device of a conventional CD-RW;

FIG. 2 is a schematic view about the current of a laser diode when a conventional CD-RW is operated;

FIG. 3 is the circuit of a read/write device of a conventional CD-RW;

FIG. 4 is a schematic view showing the write-control signal of a write-control device of a conventional CD-RW;

FIG. 5 is a circuit of the write-control device of an optical storage device of the present invention;

FIGS. 6 to 8 show the equivalent circuits of the write-control system of the present invention; and

FIG. 9 shows the control signal timing of the write-control device in the optical storage system of the present invention.

BRIEF DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. 5, a write-control device 20 of an optical storage system in accordance with one preferred embodiment of the present invention is illustrated. The write-control device 20 includes an operational amplifier 201, a first gain amplifier 202, a second gain amplifier 203, a sampling and holding circuit 204, seven switches 211–217, an OR gate 205, resistors Ri2 and Rf2 and a capacitor C2. The write-control device 20

controls the read/write head 30 of the CD-RW for reading data from a compact disk (for example the re-writable compact disk 40 shown in Fig. 1).

An input end of the sampling and holding circuit 204 of the write-control device 20 receives the feedback signal FPDO from the read/write head 30 and an output end thereof is connected to an input end of the first gain amplifier 202. An output end of the first gain amplifier 202 is connected to a first end 2111 of the first switch 211. A second end 2112 of the first switch 211 is coupled to a first end 2131 of the third switch 213, a first end 2151 of the fifth switch 215 and an external feedback resistor Rf2 and the capacitor C2 through a resistor 206. The first end 2121 of the second switch 212 is connected to a negative input end of the operational amplifier 201 and the second end 2122 thereof is connected to an output end of the operational amplifier 201. A second end 2132 of the third switch 213 is connected to the first end 2121 of the second switch 212 and the negative input end of the operational amplifier 201. A positive input end of the operational amplifier 201 is connected to a connecting end 2141 of the fourth switch 214, and an output end of the operational amplifier 201 is connected to a first switching end 2172 of the seventh switch 217 and other ends of the resistor Rf2 and the capacitor C2. Moreover, a write-control signal VWDC is outputted to the read/write head 30. A connection end 2171 of the seventh switch 217 is connected to an input end of the second gain amplifier 203 and the second switching end 2173 thereof is connected to a first switching end 2162 of the sixth switch 216 and receives control signal DAC2. A switch control signal VW2DCPS serves to control the connection end 2171 of the seventh switch 217 to be connected to the first switching end 2172 or the second switching end 2173. An output end of the second gain amplifier 203 is connected to a first switching end 2142 of the fourth switch 214. A

connection end 2161 of the sixth switch 216 is connected to the second switching end 2143 of the fourth switch 214 and the second end 2152 of the fifth switch 215. The second switching end 2163 of the sixth switch 216 is connected to ground. The sixth switch 216 is controlled by logic OR results of the time period control signals VLOON and WLDON to determine whether the connecting end 2161 is connected to the first switching end 2162 or the second switching end 2163. The WLDON is an indication signal for the write operation. When WLDON is at a high level, it represents that the read/write head 30 is in a write state. VLOON is an indication signal for pre-charging. When VLOON is at high level, it represents that the read/write head 30 is at a pre-charging state. Besides, the switches 211 to 215 can be switched based on respective control signals, while the sixth switch 216 and seventh switch 217 are connected to different switching ends based on respective control signals.

The write-control device 20 can provide the following three circuit configurations based on the states of the switches 211 to 217.

(1) Short-term open (SO) mode: In this mode, the first switch 211 is turned off, the second switch 212 is turned on and the third switch 213 is turned off. The connection end 2141 of the fourth switch 214 is connected to the second switching end 2143. The fifth switch 215 is turned off and the signals VLOON, WLDON, and VW2DCPS are at low level so that the connection end 2161 of the sixth switch 216 is connected to the second switching end 2163. The connection end 2171 of the seventh switch 217 is connected to the second switching end 2173. An equivalent circuit of this short-term mode is illustrated in FIG. 6. Obviously, in the SO mode, to match the low levels of the VLOON, WLDON and VW2DCPS, and the switching states of the switches 211 to 217, the negative input end of the operational

amplifier 201 is coupled to the output end and the positive input end is grounded so as to form a voltage follower. Since the voltage of the write-control signal VWDC has a zero level to meet the virtual grounding of the positive and negative input ends, the write-control signal VWDC can be initiated.

(2) Long term open (LO) mode: In this mode, the first switch 211 is turned off, the second switch 212 is turned on and the third switch 213 is turned off. The connection end 2141 of the fourth switch 214 is connected to the first switching end 2142. The fifth switch 215 is turned on and the signal VLOON is at a high level, and WLDON and VW2DCPS are at low level so that the connection end 2161 of the sixth switch 216 is connected to the first switching end 2162. The connection end 2171 of the seventh switch 217 is connected to the second switching end 2173. An equivalent circuit of this long-term mode is illustrated in FIG. 7. Obviously, in this mode, to match the high level of VLOON, the low levels of the WLDON and VW2DCPS and the switching states of the switches 211 to 217, the negative input end of the operational amplifier 201 is coupled to the output end and the positive input end is coupled to the second gain amplifier 203 so as to receive the amplified digital to analog control signal DAC2. It should be noted that, after the DAC2 is amplified by the second gain amplifier 203, the DAC2 level thereof will be pulled up to V2 from V1 which is a level for CD-RW. Besides, since the positive input end and the negative input end of the operational amplifier 201 are at virtual grounding states, the voltage of the write-control signal VWDC is rapidly charged from zero to a voltage V2 for writing to a CD.

(3) Closed Loop (CL) mode: In this mode, the first switch 211 is turned on, the second switch 212 is turned off and the third switch 213 is turned on. The connection end 2141 of the fourth switch 214 is connected to

the second switching end 2143. The fifth switch 215 is turned off and the signals VLOON, WLDON, and VW2DCPS are at high level so that the connection end 2161 of the sixth switch 216 is connected to the first switching end 2162. (The connection end 2171 of the seventh switch 217 is connected to the first switching end 2172.) An equivalent circuit of this closed-loop mode is illustrated in FIG. 8. Obviously, in this mode, to match the low level of VLOON, the high levels of the WLDON and VW2DCPS and the switching states of the switches 211 to 217, the operation of the operational amplifier 201 is same as the conventional write-control device 20 for recording data to a CD. At this time, the positive input end of the operational amplifier 201 is inputted with a DAC2 signal having a voltage level of V1 and the negative input end thereof is coupled to the sampling and holding circuit 204 and the first gain amplifier 202 through the resistor Ri2. A feedback signal FPDO from the read/write head 30 is inputted to the sampling and holding circuit 204, and then processed by the first gain amplifier 202 then inputted to the negative input end of the operational amplifier 201 through the resistor Ri2. The output end of the operational amplifier 201 retains a level of V2 (i.e., a voltage for recording the CD) for recording data to the CD.

In the above operation, before writing data to a CD, the gain parameter of the second gain amplifier 203 of the write-control device 20 is adjusted. That is, the write-control device 20 is switched to the closed loop mode for recording data onto a recording testing area of a CD. If the operation is successful, the voltage level V1 of the digital to analog signal DAC2 and the voltage level V2 of the write-control signal VWDC are indicated. Then, the gain of the second gain amplifier 203 is adjusted to V2/V1 by a gain adjust control signal W2BGS. Thereby, the initiation operation is completed. It is

noted that when the recording operation is completed, a short-term mode can be performed again for initializing the write-control signal as zero so that no DC offset existing. Thus, the object of low power consumption is achieved.

FIG. 9 shows the timing clock for one writing operation of the write-control device 20. The writing operation includes four time periods T1 to T4. In time period T1, the time period control signal VLOON and WLDON are at low level and the write-control device 20 is in the short-term open mode. At this mode, the positive input end of the operational amplifier 201 is grounded and the negative input end thereof is connected to the output end so as to form a voltage follower. The voltage of the write-control signal VWDC is virtually grounded so that the level is reduced to zero. Thus, the write-control signal is initiated.

In time period T2, the time period control signal VLOON is at high level, and WLDON is at low level, the write control device 20 is switched to a long-term open mode. At this mode, the second gain amplifier 203 amplifies the voltage of digital to analog signal DAC2 from V1 to V2. As the write-control signal VWDC is virtually grounded, it can be quickly charged to the voltage V2 for recording data onto a CD, as shown in the path A of FIG. 9, rather than slowly charged to the voltage V2 by a capacitor.

In time period T3, the time period control signal VLDON and WLDON are both at high level and the write control device 20 is switched to closed-loop mode. As the conventional write-control device, the write-control device 20 can perform the recording operation normally.

In time period T4, since the recording operation is completed, the time period control signals VLOON and WLDON return to low level, and the

write control device 20 is switched to the short-term open mode, whereby the voltage of the write control signal VWDC can be reset to zero.

From the above description, it is known that the write-control device 20 of the present invention generates the time period control signal VLOON so that the write-control signal VWDC charges to the capacitor C2 in advance to achieve a working voltage. When the time period control signal WLDON becomes high level for writing data, since the write-control signal VWDC has been charged to the working voltage, the current i_D of the laser diode LD is at a value for writing data onto a CD. Thus, the errors of the laser diode when writing data due to insufficient current can be avoided. Besides, by the present invention, when the CD-RW is not in a writing operation, the voltage of the write-control signal VWDC can be set as zero so that no DC bias problem generates. Furthermore, the above signals, such as FPDO, VLOON, WLDON, VWDC, VW2DCPS, W2BGS may be referred to VT3190 chips manufactured by VIA Optical Solution, INC. It is noted that in the present invention, the write control device is suitable for any photoelectric system that has a writing operation supported by a photoelectric effect, for example, CD-RW or DVD-RW. In addition, the present invention can be used in other systems, such as CD-RW disk, CD-R disk, etc.

The present invention is thus described, and it will be obvious that the same may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the present invention, and all such modifications as would be obvious to one skilled in the art are intended to be included within the scope of the following claims.